Wind-Turbulence-Wave Interactions

Carl A. Friehe
Departments of Mechanical Engineering and Earth System Science
University of California, Irvine
Irvine, CA 92697-3975
Phone (949) 824-6259 Fax (949) 824-2249 email: cfriehe@uci.edu

Award #: N000149610061
http://wave.eng.uci.edu

LONG-TERM GOALS

The long-terms goals of the research are to understand and parameterize the physics of air –sea interaction, and in particular wind-wave interaction. The effort is primarily experimental, based on measurements over the sea under a variety of wind-wave conditions. Applications are to EO propagation and scintillation over the ocean.

OBJECTIVES

The objective is to develop similarity parameterizations of air-sea interaction and the MABL. Underlying this is the improvement of the basic understanding of wind-wave physics.

APPROACH

The approach is in-depth analysis of the wind, turbulence and wave data obtained in the Marine Boundary Layers ARI experiment from R/P *FLIP*. Approximately 7 GB of data were obtained. Spectral, statistical and other analyses are applied to the data to determine the physics of wind-wave interaction and parameterizations of air-sea interaction. Theoretical analyses of atmospheric turbulence are undertaken.

WORK COMPLETED

Work has focussed on the interpretation of the wind, wave and wind stress results obtained from the MBL data set. A theoretical analysis of surface fluxes was undertaken to determine the corrections necessary when there are finite mass (e.g., evaporation) and heat fluxes at the surface. The work cleared up previous misunderstandings and extended the corrections to momentum transfer (wind stress).

RESULTS

The surface layer turbulence structure over wind waves and swell is found to be different from that over land. The common assumption for the surface layer is that there is negligible stress divergence. Stress divergence appears to be more important and higher wind speeds, with accompanying higher waves. This is shown in Figure 1, where the stress at the canonical 10-meter height is plotted versus the stress extrapolated to the surface. At the highest speed conditions of the MBL experiment, the surface stress exceeds the 10-meter stress by 40%.

Report Documentation Page

Form Approved
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
30 SEP 2001		**00-00-2001 to 00-00-2001**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Wind-Turbulence-Wave Interactions	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Departments of Mechanical Engineering and Earth System Science,,University of California, Irvine,,Irvine,,CA, 92697**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
The long-terms goals of the research are to understand and parameterize the physics of air ???sea interaction, and in particular wind-wave interaction. The effort is primarily experimental, based on measurements over the sea under a variety of wind-wave conditions. Applications are to EO propagation and scintillation over the ocean.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**5**	

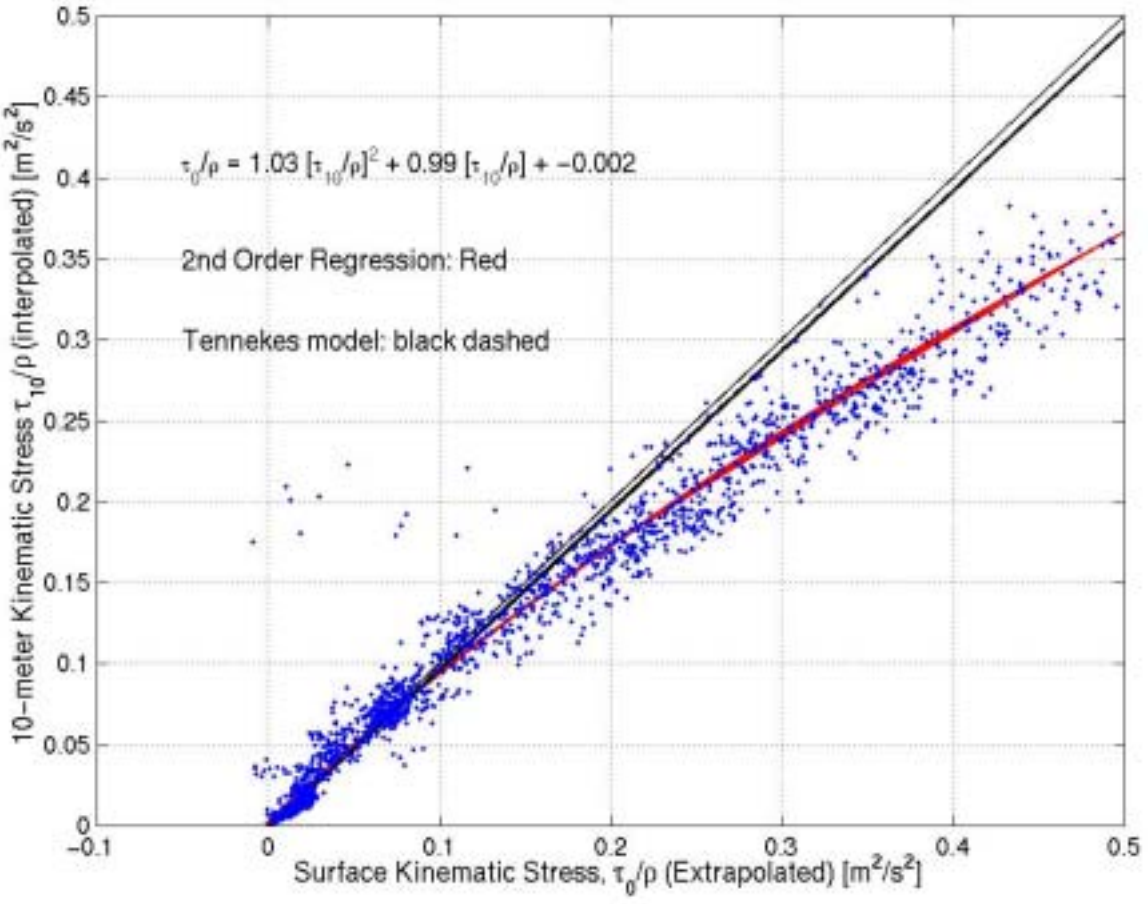

Figure 1: Kinematic wind stress at 10-meter height and the surface from the MBL experiment on R/P FLIP. Solid lines are 1:1 and Tennekes' model; red line is the second-order regression.

The corrections to surface sensible heat, latent heat, momentum and trace gas species fluxes were derived. For the first time, corrections to the momentum flux were obtained.

IMPACT/APPLICATIONS

The impacts of the research will be in the improvement of the basic understanding of air-sea interaction processes in particular the physics of wind-wave coupling. The research will lead to better parameterizations of air-sea interaction, such as the wind stress, through incorporation of wave effects.

The result of significant stress divergence in the lower 20 m above the waves in high winds should have impacts on wave forecasting models and large-scale weather models. The results of the 10-meter drag coefficient are shown in Figure 2, where the MBL values are plotted together with the formula of Garratt. The formula underestimates the surface stress above 8 meters per second wind speeds up to 70% due to the neglect of stress divergence.

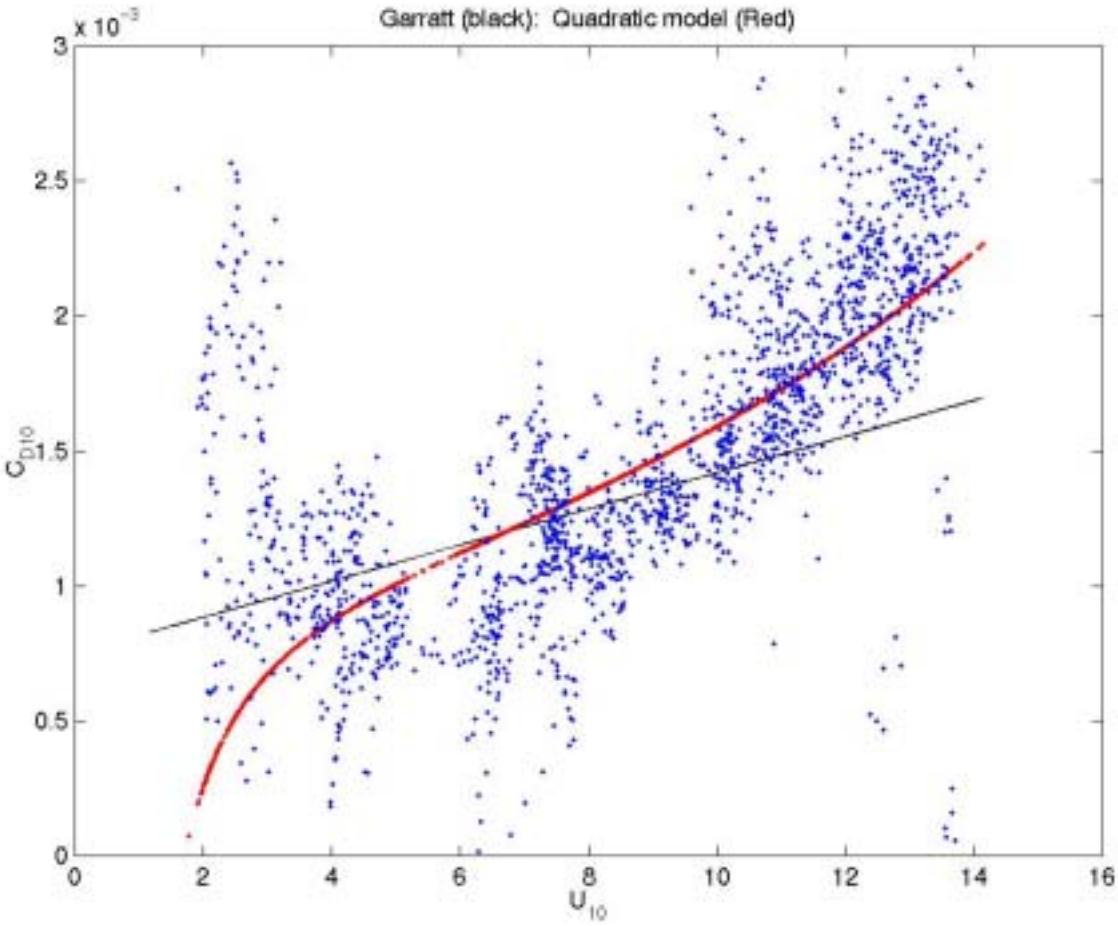

Figure 2: MBL Drag Coefficient and Garratt's Compilation (black line). Red Line is Quadratic Model Accounting for Stress Divergence.

The corrections to surface fluxes will be of use for past and future eddy correlation flux measurements.

TRANSITIONS

We are working with the Navy Space and Warfare Systems Command, SPAWAR about measurements and wave effects on radar and optical propagation in the surface layer over the ocean. We are preparing for an experiment, Rough Evaporation Duct, to be conducted on the Research Platform *FLIP* in fall 2001.

RELATED PROJECTS

This project is related to our participation in the SPAWAR RED experiment.

PUBLICATIONS

Journal Papers

Friehe, C. A., Smith, J. A., Rieder, K. F., Huang, N. E., Giovanangeli, J-P, and Geernaert, G., "Wind, Stress and Wave Directions," in *Wind Stress Over the Ocean*, I. S. F. Jones, and Y. Toba, eds., Cambridge University Press, 2001 in press.

Fuehrer, P. F. and Friehe, C. A., "Flux Corrections Re-Visited," accepted *Boundary-Layer Meteorology* 2001.